

1       **GOLF CLUB HEAD AND METHOD OF FABRICATING THE SAME**

2       **BACKGROUND OF THE INVENTION**

3       1. Field of the Invention

4               The present invention relates to a golf club head and a method of  
5       fabricating the same, and more particularly to a golf club head has a faceplate  
6       with a modified sweet spot to cause a golf ball to travel a farther distance.

7       2. Description of Related Art

8               Types of golf clubs are woods, irons and putters. Each of them has a grip,  
9       a shaft and a head. The shaft has two ends. The grip is attached to one end of the  
10      shaft, and the head is attached to the other end of the shaft. The grip is used by a  
11      golfer to hold the club, and the head is used to hit balls. The head on a club with  
12      a longer shaft hits a ball a greater distance. To hit the ball powerfully and  
13      successfully, the head of the golf club is made of high strength material such as  
14      metal or composite materials.

15             Generally speaking, a golfer hits balls with a swing speed from 30 to 50  
16      meters per second (m/s) with an impact duration of about 0.0045 second. To  
17      consistently ensure powerfully and successfully striking a ball, all conditions of  
18      the head must be stable. The club head has a face with a faceplate designed to  
19      make direct contact with a ball so increased stiffness of the faceplate can help the  
20      golfer strike a ball powerfully. Some methods for increasing the stiffness of the  
21      faceplate have been developed. One of them is to add ribs in the head to bear the  
22      force of impact when the head strikes the ball.

23             With reference to Fig. 9, a golf club head in accordance with the prior art  
24      includes an empty body (50), a crown empty member (51) and ribs (52). The

1 body (50) has a front side (not numbered), a rear side (not numbered), a face  
2 (501), a hosel (502) and a shank (503). The hosel (502) is defined in shank (503)  
3 and is adapted to attach to a shaft (60). The face (501) with a faceplate (not  
4 numbered) is attached to or formed on the body (50) at the front side and is  
5 adapted to hit the balls. The ribs (52) are mounted in the body (50) behind the  
6 faceplate of the face (501) to increase the stiffness of faceplate of the face (501)  
7 to hit the ball powerfully. The crown empty member (51) is attached to the body  
8 (50) at the rear side to cover the body (50). With reference Fig. 10, another  
9 conventional metal wood golf club head has a structure similar to the golf club  
10 head previously described. The metal wood golf club head has an empty body  
11 (50') with a faceplate (not numbered) and a spiral rib (52') mounted on the back  
12 of the faceplate of the body (50') to increase the stiffness of the faceplate.

13 Also, another way to increase the stiffness of the face is to attach a high  
14 strength, reinforced plate to the face of the head. With reference to Figs. 11 and  
15 12, a reinforced plate (63) is attached to the face (501) attached to the body (50).  
16 The reinforced plate (63) has high strength and makes the face (501) thicker to  
17 increase the stiffness of the face (501).

18 Furthermore, increasing toughness of the faceplate of the face (501) will  
19 increase the impact duration and help the golfer to maintain ball velocity on  
20 off-center hits. The increased toughness will dampen harsh-feeling vibrational  
21 frequencies that occur at impact. However, the stiffness and the toughness of the  
22 same material are inversely proportional mechanical properties, which means if  
23 the stiffness is increased, the toughness will decrease.

24 To overcome the shortcomings, the present invention provides a golf

1 club head and method for fabricating the same to mitigate or obviate the  
2 aforementioned problems.

### 3 SUMMARY OF THE INVENTION

4 Generally, a golf club head includes a body and a faceplate. The body  
5 has a face adapted to hit balls and the faceplate is attached or formed firmly to  
6 the face of the body. The faceplate in accordance with the present invention has a  
7 center of percussion and a softened region. The center of percussion, called a  
8 “sweet spot,” is the best point to hit the balls, and the softened region that is  
9 formed by a heat treatment technique is formed around the sweet spot of the  
10 faceplate. Thickness of the faceplate attached to the face of body of the golf club  
11 head is about 2.1 to 2.3 millimeters (mm). Tensile strength of the faceplate is  
12 required to be from 100 to 120 ksi (kilo-psi), and the higher, the better. The  
13 faceplate is generally made of high strength materials such as maraging steel,  
14 near  $\beta$ -phase titanium (Ti) alloy or the like.

15 Another factor that influences hitting the balls is called the coefficient of  
16 restitution or “COR” and relates to the energy transfer that occurs when the  
17 faceplate impacts a ball. COR directly relates to the speed of the ball as it  
18 rebounds from the faceplate. Generally, a faceplate with a higher COR will  
19 generate greater ball velocity that results in more distance.

20 For form the softened region, the heat treatment technique in accordance  
21 with the present invention comprises:

22 locating a copper tubing on a faceplate over the region to be softened;  
23 applying a high-frequency current to the copper tubing to create a time-  
24 varying magnetic field which induces heat in the region of the faceplate to be

1     softened; and

2             removing the copper tubing from the softened region of the faceplate.

3             The softened region can increase the COR of the faceplate and cause a  
4     ball to travel a greater distance. Consequently, the faceplate has a high strength  
5     sweet spot and higher COR to hit the ball powerfully and successfully.

6             The main objective of the invention is to provide a golf club head with a  
7     high strength sweet spot and a softened region around the sweet spot to increase  
8     the COR of the golf club head to hit balls powerfully and successfully.

9             Another objective of the invention is to provide a heat treatment  
10    technique to form the softened region of the faceplate by applying a high-  
11    frequency current to a copper tubing that is positioned over the faceplate.

12            Other objectives, advantages and novel features of the invention will  
13    become more apparent from the following detailed description when taken in  
14    conjunction with the accompanying drawings.

15    BRIEF DESCRIPTION OF THE DRAWINGS

16            Fig. 1a is a perspective view of a metal wood golf club head in  
17    accordance with the present invention;

18            Fig. 1b is a perspective view of an iron golf club head in accordance with  
19    the present invention;

20            Fig. 2 is a schematic of a high-frequency induction heating machine that  
21    uses a high-frequency current heat treatment technique;

22            Fig. 3 is a top plan view showing a faceplate of the golf club head in Figs.  
23    1 and 2 being annealed by a copper tubing of the high-frequency induction  
24    heating machine in Fig. 2;

1            Fig. 4 is a graph of the hardness of the sweet spot of the faceplate in Fig.  
2            3 before heating and after heating;

3            Fig. 5 is a graph the skin depth of the high-frequency current for a  
4            specific frequency;

5            Fig. 6 is a graph of the output power as a function of the frequency of the  
6            high-frequency current;

7            Fig. 7 is a graph of the acting time that the high-frequency current  
8            required to be active as a function of the frequency of the high-frequency  
9            current;

10           Fig. 8 is a table of the results of impact test;

11           Fig. 9 is a cutaway exploded perspective rear view of a conventional a  
12           golf club head;

13           Fig. 10 is a cross sectional rear plan view of a conventional a metal wood  
14           golf club head;

15           Fig. 11 is a cross sectional side plan view of a conventional iron golf  
16           club head; and

17           Fig. 12 is a cross sectional side plan view of another conventional metal  
18           wood golf club head.

19           DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

20           With reference to Figs. 1a, 1b and 3, a golf club head (10) for an iron or a  
21           wood in accordance with the present invention includes a body (11) and a  
22           faceplate (12). The body (11) has a hosel (110), a face (111) and a shank (112).  
23           The hosel (110) is defined at the shank (112) and is adapted to connect to a shaft  
24           (not shown) of the golf club. The face (111) is formed on the body (11) and is

1 adapted to hit a golf ball (not shown). The face (111) may be a recess in which  
2 the faceplate (12) is mounted.

3 The faceplate (12) is attached firmly to or formed integrally on the face  
4 (111) of the body (11) by welding, forging or other means and has a center of  
5 percussion, called a "sweet spot," and a softened region (121). The sweet spot  
6 represents the spot of desired contact with the ball, and the softened region (121)  
7 is formed around the sweet spot by a heat treatment technique. The faceplate (12)  
8 is made out of high strength precipitation hardening stainless steel (typical of  
9 such stainless steel materials is 17-4PH (American Iron and Steel Institute, AISI.  
10 No. 630), AISI. No. 455 or 465), titanium (Ti) alloys (typical of such titanium  
11 alloys is Ti-6Al-4V, 15-3-3-3Ti, Ti-10V-2Fe-3Al, or Ti-20V-4Al-1Sn) or other  
12 high strength iron-based materials (typical of such iron-based materials is Fe-  
13 9Al-28Mn-1C-6Cr).

14 With reference to Fig. 2 and 3, the heat treatment technique to form the  
15 softened region (121) on the faceplate (12) uses a high-frequency induction  
16 heating machine. The high-frequency induction heating machine includes a  
17 power control box (20), a high-frequency current generator (21), a weight load  
18 (22), copper tubing (23) and a base (24). The faceplate (12) is mounted on the  
19 base (24), and the copper tubing (23) is positioned over the faceplate (12). The  
20 weight load (22) creates a force (F) perpendicular to the faceplate (12) to press  
21 the copper tubing (23) against the faceplate (12). The copper tubing (23) is  
22 electrically connected to the high-frequency current generator (21) that is  
23 controlled by the power control box (20). When the power control box (20) is  
24 turned on, the high-frequency current generator (21) generates a high-frequency

1 current and applies to the high-frequency current to the copper tubing (23). A  
2 time-varying magnetic field will be generated around the copper tubing (23), and  
3 magnetic flux of the magnetic field induces internal currents, as known as eddy  
4 currents, in the faceplate (12). Part of the magnetic energy will be lost, called  
5 eddy-current lose, which is converted to thermal energy to locally heat the  
6 faceplate (12) for annealing to form the softened region (121) in the faceplate (12)  
7 under the copper tubing (23).

8         With reference to Fig. 5, skin depth represents the depth at which the  
9 eddy current density induced in the faceplate (12) by the high-frequency current  
10 works is sufficient to anneal the metal in the faceplate (12). As the frequency of  
11 the high-frequency current increases, the skin depth is shallower. This  
12 phenomenon is called “skin effect”. With reference to Fig. 6, as the frequency of  
13 the high-frequency current increases, the output power of the high-frequency  
14 current increases, too. This phenomenon is used to heat the metal to a required  
15 temperature for annealing in a very short time with a large output power. With  
16 reference to Fig. 7, when the output power of the high-frequency current is large,  
17 the acting time is short.

18         Therefor, the thermal energy converted from the magnetic energy is a  
19 function of the frequency and the output power of the high-frequency current  
20 and the acting time. For example, a high-frequency current with 80 kilowatts of  
21 output power is applied to a faceplate (12), which is made of titanium alloy (Ti-  
22 20V-4Al-1Sn) for 8 seconds. When the high-frequency current is applied to the  
23 copper tubing (23) that heats the faceplate (12) around the sweet spot, the grain  
24 structure of the softened region (121) is changed by the heat, and the mechanical

1 properties of the softened region (121) are different from the other area. After the  
2 heat acts on the metal, the grain size of the softened region (121) becomes 2 to 4  
3 times larger than before. With reference to Fig. 4, wherein the distance  
4 represents a width of the softened region (121) on the faceplate (12), the  
5 unheated faceplate (12) has a uniform hardness (A). After heating the faceplate  
6 (12), the hardness (B) of the faceplate (12) varies around the sweet spot, and a  
7 hardness difference between the softened region (121) and the sweet spot is from  
8 20 to 22 H<sub>R</sub>C.

9         Based on experimental result, some best control conditions for  
10 processing the faceplate (12) with a thickness from 2.1 to 2.3 mm are summed up  
11 as follows.

- 12         1. The frequency of the high-frequency current is 50 to 2000 Hz.
- 13         2. The output power of the high-frequency current is 10 to 150 kilowatts.
- 14         3. The high-frequency current is applied for 0.5 to 10 second(s).
- 15         4. An outer diameter of the copper tubing (23) is 3 to 8 millimeters.
- 16         5. A distance between the copper tubing (23) and the faceplate (12) is 1.5  
17 to 3 millimeters.

18         With reference to Fig. 8, impact tests were performed to confirm the  
19 improvement in the coefficient of restitution (COR) effects of the present  
20 invention to the faceplate (12).

21         From items 1 to 5 in Fig. 8, the faceplate (12) is made of titanium alloy  
22 (Ti-20V-4Al-1Sn), and attached to the face of the head of a driver (No.1 wood)  
23 with a 9.5-degree launch angle, and a volume of the head is 400 cubic  
24 centimeters (cc).



1           From items 6 to 10 in Fig. 8, the faceplate (12) is made of maraging steel  
2   (AISI. No. 465), and attached to the face of the head of a driver (No.1 wood)  
3   with a 9.5-degree launch angle, and a volume of the head is 310 cubic  
4   centimeters (cc).

5           From items 11 to 15 in Fig. 8, the faceplate (12) is made of Fe-base  
6   materials (Fe-9Al-28Mn-1C-6Cr), and attached to the face of the head of a driver  
7   (No.1 wood) with a 9.5-degree launch angle, and a volume of the head is 320  
8   cubic centimeters (cc).

9           From items 16 to 20 in Fig. 8, the faceplate (12) is made of stainless steel  
10   (17-4PH), and attached to the face of the head of a driver (No.1 wood) with a  
11   9.5-degree launch angle, and a volume of the head is 270 cubic centimeters (cc).

12           The test results clearly show that the coefficient of restitution (COR) of  
13   the faceplate (12) is improved after the heating treatment technique is performed.  
14   Items 5, 10, 15 and 20 show another interesting result that excessive heating will  
15   decrease the COR of the faceplate (12). Therefor, keeping the control conditions  
16   within the limits shown above is important when processing the faceplate (12).

17           From the above description, the present invention can really not improve  
18   the coefficient of restitution of the golf club head to hit the ball successfully but  
19   retain the strength of the sweet spot of the golf club head to hit the ball  
20   powerfully.

21           Even though numerous characteristics and advantages of the present  
22   invention have been set forth in the foregoing description, together with details  
23   of the structure and function of the invention, the disclosure is illustrative only,  
24   and changes may be made in detail, especially in matters of shape, size, and

- 1 arrangement of parts within the principles of the invention to the full extent
- 2 indicated by the broad general meaning of the terms in which the appended
- 3 claims are expressed.